Report No. 97/EE/67 1998

Natural resource accounting in Goa

Background paper
Prepared for
Department of Statistics
Ministry of Planning and Programme Implementation
Government of India

Policy Analysis Division
Tata Energy Research Institute

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Summary

We propose to

- develop physical accounts of natural resource depletion or enhancement and environmental degradation or improvement;
- value, in economic terms, natural resource depletion or enhancement and environmental degradation or improvement (to the extent possible);
- adjust state domestic product to account for natural resource depletion or enhancement and environmental degradation or improvement.

Summary table

Accounts	*Description*	*Secondary data*	*Survey*	*Previous related work by TERI*
Land-use	Either tabulation or on GIS	DPSE, Goa ; NRSA; other state agencies		Mapped mining areas in Goa on GIS; will map coastal areas
Minerals	Physical accounts; valuation by net price and user cost	Regional office of the Indian Bureau of Mines		Mineral accounts for Yamuna sub-basin
Forests	Physical accounts; use-values by market prices; non use-values by contingent valuation	State of the Forest Report; Working Plans	Survey of 400 respondents proposed for contingent valuation	Valuation of use values of forest for states in India
Groundwater resources	Physical accounts; valuation by incremental costs of extraction	Groundwater Resources of India; unpublished data with State Groundwater Board		Estimation of incremental costs of groundwater extraction in Haryana
Water degradation	Estimation of loadings of COD or BOD; maintenance costs	Very limited	Drinking water samples from 400 households; effluent concentration monitoring in 60 locations	Estimated incremental annual costs of ensuring drinking water security
Air degradation	Emissions inventory and exposure accounts; maintenance costs	For emissions, adequate; for exposures, especially of miners, very inadequate	Baseline socio-economic and time budget survey of 1000 households; exposure monitoring of 100 households, of which 50 of miners	Valuation of costs and benefits of air pollution control in Delhi using total exposure method
Solid waste	Physical accounts only - households and tourism waste and by components	Very inadequate	Collection of waste, and component analysis for 400 households and for hotels	Surveys of waste management in different cities

How will the output from the study be useful?

The output will serve two main functions: (1) scorekeeping; by indicating the extent to which the environment affects the development record and (2) management; by providing information that is essential to sound environmental management. For example, forests are known to confer a variety of benefits. An assessment of people's willingness-to-pay for these benefits will be useful in other situations where a quick decision has to be made on the relative merits of preservation against development. Another application is the use of the information base on the generation and impacts of pollution, which is a necessary input into management of pollution. The emissions of different air pollutants is a logical starting point for abating air pollution, while the exposures of mining communities to air pollution may help address health issues of this vulnerable group, and about which we at present have very limited information.

1 Introduction

What led to this paper?

Technical Working Group in CSO

This background paper has been prepared for , and sponsored by, the Central Statistical Organization, Government of India. Around the middle of last year, the Director of Planning, Statistics and Evaluation, Government of Goa had prepared a revised proposal concerning natural resource accounting in Goa for the three sectors of mining, coastal tourism and forestry. A Technical Working Group set up by the Department under the Chairmanship of the Secretary, Department of Statistics, had met on the 19th of November, 1997, to discuss this revised proposal. At this meeting, it was decided that TERI would prepare a detailed background paper , incorporating the ' methodology to be followed, availability of data from secondary sources, fresh collection of primary data, the duration of the project and estimated cost and modalities of implementation.'

Project design considerations

The members of the Technical Working Group made detailed comments on the revised proposal, 'Natural Resource Accounts for the States of Goa – an exploratory exercise,' submitted by the Director of Planning, Statistics and Evaluation, Government of Goa. The concerns of the members of the Technical Working Group are listed below. We have addressed these concerns in the background paper, after consulting officials in the Directorate of Planning, Statistics and Evaluation, Government of Goa.

- What time period, and years will be studied by the project? If possible, the accounts should be built for two or more years. We suggest that they be built for 1991 and 1996.
- What sectors are going to be included? Three sectors (mining, forestry, and tourism) may be too restrictive.
- What data is available now? We have identified the data that is available from secondary sources, and the data that will have to be gathered through primary surveys.
- How will the project be operationalised? By one or more research institutes working in close collaboration with a small team from the Directorate of Planning, Statistics and Evaluation, Government of Goa, and other departments of Government of Goa such as Environment, Forestry, Town and Country Planning, Minerals etc. The success of the project will hinge on

availability of data from different government departments, and on participation by an inter-disciplinary team from the State Government.

- How will the project be replicated in other states? The project needs to be designed keeping in mind the need for replication in other states.
- What methodology will be followed? A detailed methodology needs to be agreed to by the committee, and is proposed in this paper.
- To what extent will the accounting be in physical terms and to what extent will it be in monetary terms? Physical accounting is important, by itself, and also, as a pre-requisite to environmental accounting.
- Will the project only study natural resource depletion or will environmental impacts also be studied? The project will study both natural resource depletion and environmental impacts.

Objective of NRA in Goa

Related to a number of sectors of economic activity, to

- develop physical accounts of natural resource depletion or enhancement and environmental degradation or improvement;
- value, in economic terms, natural resource depletion or enhancement and environmental degradation or improvement (to the extent possible);
- adjust state domestic product to account for natural resource depletion or enhancement and environmental degradation or improvement.

Past work in Natural Resource Accounting

Increasingly widespread

There is now an extensive literature, which addresses conceptual issues as well as empirical investigation, both for developed and developing economies. An idea of the diversity and extent of work currently in progress can be gauged by a glance at the papers of the International Symposium on Integrated Environmental and Economic Accounting in Theory and Practice, held in Tokyo, Japan, in March 1996. There are papers on country experiences in such diverse locales as Namibia and Costa Rica. The Philippines had the distinction of two distinct exercises in natural resource accounting! Among the issues discussed at the workshop were the role of modelling, the role of physical versus monetary accounts, and geographical aspects of natural resource accounts. Less well known, though, is the fact that there is now an 'Indian' literature on Natural Resource Accounting, both conceptual and empirical. This section will briefly look at the reasons for doing natural resource accounting, the different approaches to natural resource accounting, and the Indian contributions to this activity.

Reasons for natural resource accounting

Natural resource accounting is a response to three criticisms of the conventional national economic accounts (Peskin 1996):

1. Such measures as the gross national product (GNP), do not adequately reflect the degradation of the nation's environment. For instance, efforts to clean up an oil spill or increased health expenditures necessitated by poor air quality would tend to increase national production even though these actions could be no more than an attempt to maintain environmental quality at an acceptable, pre-pollution level.
2. The conventional accounts treat reproducible wealth and natural wealth inconsistently. Whereas in the case of man-made assets, a depreciation allowance is subtracted from gross income to estimate net income, no such depreciation allowance is subtracted for the depreciation of natural wealth.
3. Conventional accounts are incomplete in that they neglect important inputs and outputs in the nation's 'production function' – inputs and outputs that have economic significance but are neglected because they lack market-determined values and prices. For instance, water bodies absorb pollutants, which flow into them, but this service is not accounted for in the traditional accounts.

Alternative approaches

Peskin (1996) is an excellent survey of alternative resource and environmental accounting concepts and their contribution to policy. According to Peskin, there are two distinct functions of natural resource accounting: (1) scorekeeping, and (2) management. GDP, for instance, fulfills a scorekeeping function when it informs policy makers about the overall state of the economy. But it is detailed information on several macro-economic variables that guides them to take corrective action, which is a management function. Different approaches, in Peskin's view, place different emphasis on scorekeeping and management, and interpret 'accounting' differently. He distinguishes four broad approaches in natural resource accounting (Table 1).

Table 1. Different approaches in natural resource accounting

Approach	*Example*	*Most suitable use*
Pollution expenditure accounting	Data series on pollution expenditures in the United States since 1972	Macro- and sectoral impact analyses
Physical accounting	Dutch input output matrix system - National Accounting Matrix including Environmental Accounts (NAMEA)	Provider of inputs to policy simulation and other programming models
'Green' indicators	NDP modified by depreciation of principal natural assets by Repetto and others	Important 'scorekeeping' function, sensitizing policy makers
Extensions of SNA type systems	UN SEEA (United Nations System for Integrated Environmental and Economic Accounting)	Close integration with the SNA, and policy targeting

Source. from Peskin (1996).

Indian work

Over the last few years, there has been a growing literature on natural resource accounting work in India. The following list is indicative of this literature.

- *Framework for natural resource accounting.* The Indira Gandhi Institute of Development Research (IGIDR 1992) prepared a framework for the Ministry of Environment and Forests, and the United Nations Development Programme sponsored this. While using the guidelines given by the United Nations in their documents as a base, this framework attempts to meet the special circumstances of the Indian case, particularly in the inclusion of non-market sectors and non-commercial fuels.
- *Adjusting GDP for depreciation of coal, soil and forests.* Perhaps the first Indian empirical estimates of natural resource degradation was the valuation of depletion of India's coal, forests and soil by TERI (TERI 1994). This study tried to highlight the discrepancies in the existing system of national income accounts and to amend these to account for natural resource depletion. Specifically, the study developed the physical accounts, valued the depletion and adjusted the gross domestic product to take note of the cost of depletion of soil, coal and forests.
- *Natural resource accounting in the Yamuna sub-basin.* The Ministry of Environment and Forests commissioned this large study of natural resource accounting in the Yamuna sub-basin. A number of institutes, including the Institute of Economic Growth, NEERI, CISMHE, and TERI, collaborated on this project. This project studied a range of resources in the region, including land, air, water, and minerals. In this project TERI built accounts for energy and emissions; accounts for minerals; analysed the impact of agricultural activities; and studied the exposures of the population in the Yamuna sub-basin to air pollution and air pollution related health impacts.

- *Theory of natural resource accounting.* Kadekodi and Agarwal (1997) have examined the theoretical basis of environmental and natural resource accounting from the viewpoint of maximizing social welfare over time.

International guidelines

In 1993, the United Nations revised the system of national accounts (SNA) for the first time in 25 years, and recommended that member countries implement it. As part of this revision, integrated environmental and economic accounting was introduced. The concept and structure of such accounting are shown in the revised SNA manual, as well as in a separately published handbook for integrated environmental and economic accounting (UN 1993). Alfieri (1996) attempts to provide a step-by-step approach in the implementation of the System of Integrated Environmental and Economic Accounting.

The Goan context

Goa is located on the west coast of India, bounded on the north by Maharashtra, on the east and south by Karnataka, and on the west by the Arabian Sea. The state has two districts and eleven talukas; six of them in North Goa and five in South Goa. The population of Goa is estimated to be about 1.17 million (1994/95) with about 59% living in the rural areas and the rest in urban areas. Goa is one of the most developed states in India. The per capita income in 1994/95 was around Rs.10,128/-, which is considerably higher than the all India figure of Rs.6,234/, and has been growing at an average annual growth rate of 4% since 1980. In terms of such human development indicators as infant mortality rate, birth rate, death rate, literacy rate, drinking water and the status of women, Goa is better off than the country as a whole.

The shares of sectoral income in the three years, 1980/81, 1984/85 and 1990/91 are presented in Table 2. The shares of the primary and secondary sectors have been decreasing, and that of the tertiary sector has been increasing. The tertiary sector dominates the economy with over 51% of the Gross State Domestic Product (GSDP) originating in this sector. In 1990/91, the tourist industry contributed about 11% of GSDP, financial and other business services about 11% and, community, social, and personal services about 12.5%. Table 3 shows the gross domestic product at factor cost by industry of origin.

Table 2. Sectoral share of gross state domestic product (%)

Year	*Primary*	*Secondary*	*Tertiary*	*Total*
1980/81	24.27	29.87	45.86	100
1984/85	22.92	29.36	47.72	100
1990/91	19.87	28.65	51.48	100

Table 3. Gross state domestic product at factor cost by industry of origin (Rs lakhs, at 1980/81 prices): 1992/93 to 1995/96

Industry of Origin	1992/93	1993/94	1994/95 (P)	1995/96(Q)
Agriculture	7419	6891	6905	6925
Forestry and Logging	231	238	271	246
Fishing	2206	2665	2525	2104
Mining and Quarrying	1968	2234	2433	2329
Manufacturing	24936	25029	26310	26234
Electricity, Gas & water supply	809	740	928	806
Construction	3175	2861	2877	2893
Trade, Hotels and Restaurants	7466	8510	8619	8535
Transport, Storage & Communication	13627	15418	15767	16950
Financial, Insurance, Real Estate & Business Services	7214	7734	8061	8194
Community, Social and Personal Services	7429	7526	7510	7908
Total Gross State Domestic Product	76580	79852	82206	83124

P: Provisional Estimates Q: Quick Estimates

Agriculture

Agriculture progressed well during the period after liberation but has been stagnant since the seventies. This is so because (1) on the one hand there are few incentives for landowners to invest in land for agriculture because of the tenurial system in place in Goa; and (2) there is high demand for land by builders, developers, industrialists, etc, who press for land conversions. In such a situation, selling land or putting land under non-agricultural activity is becoming an attractive option for landowners. Current development choices being pursued and favoured by the government are also in favour of more industries and services.

Mining

The reserves of iron in Goa were estimated to be 411 million tonnes in 1970, comprising of 81 million tonnes of lumpy ore with +60% Fe. The annual production of iron ore in Goa over the last ten years has averaged around 12 to 13 million tonnes/year. Production has been stepped up since 1994. In 1995/96, production was about 17 million tonnes. This has led to an increase in the state's income. However, nowhere is there any reflection of the fact that ore reserves are being used and that future generations will not have access to the same as

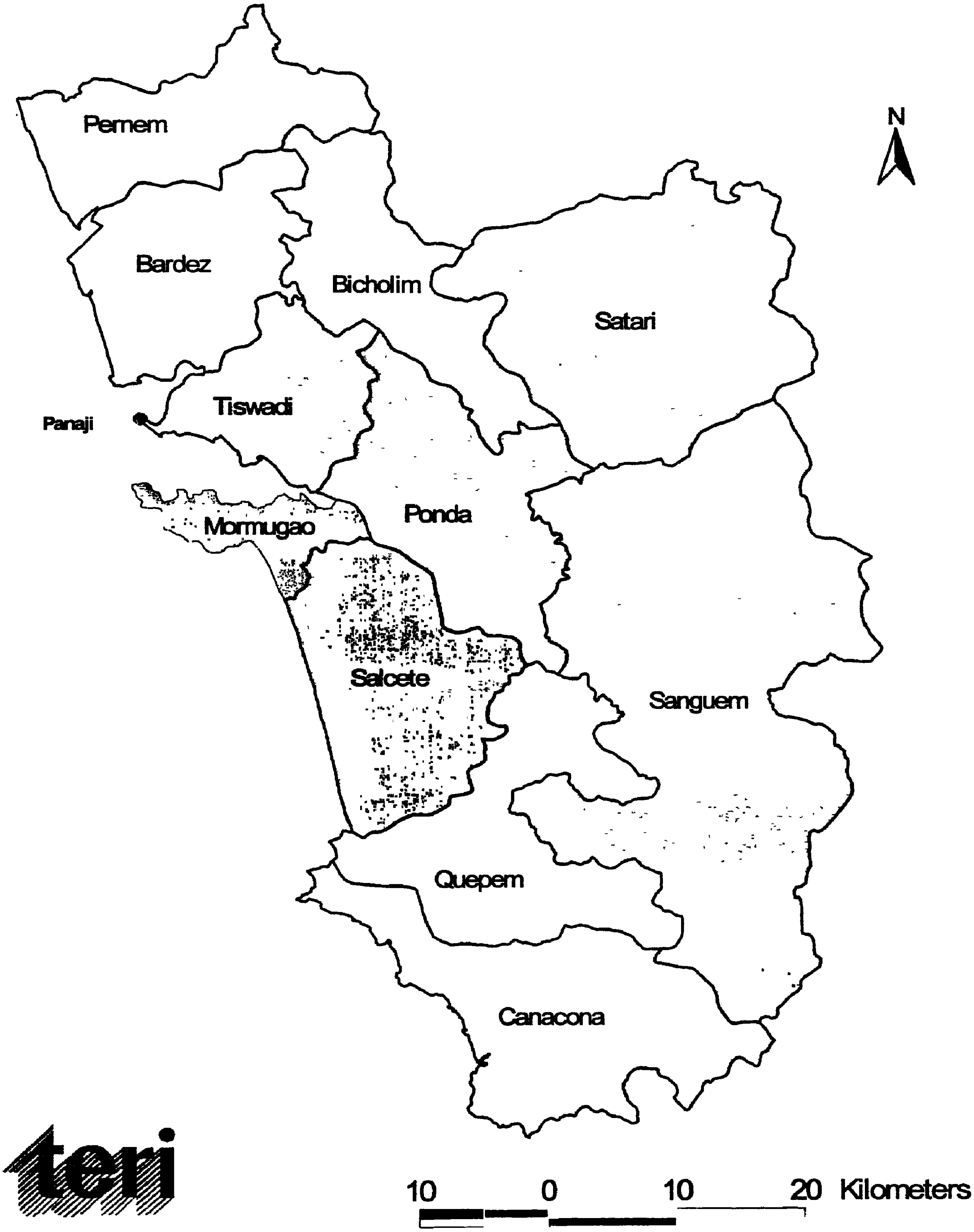

Figure 1 Goa: talukas

sources of income. Ignoring this fact, results in a non-recognition and a non-provision of measures by policy-makers that will allow a part of the income generated by these resources to be set aside and invested so that they can serve as future sources of income. Nor is there any account taken of the environmental impacts of mining activity. The process of opencast mining involves drilling, blasting, excavation of rock, overburden and ore, handling, transportation and beneficiation.

Coastal tourism

Tourism is another important economic activity in Goa, most of which is accommodated on the 105 km coastline. It is estimated that tourism contributes to around 13.7% of Net State Domestic Product; 7% to employment and 7% to state tax revenues. On an average, for the last three years the average earnings in foreign exchange are estimated to be around Rs 1500 to Rs 2000 million. While much importance is given to tourism as a source of income, little heed is paid to its environmental impacts (Sawkar et al, 1997).

Forests

The area under forests in Goa is reported as 1255 sq. km. About 90% of this is confined to the Western Ghats foothills in the talukas of Satari, Sanguem and Canacona. The forests have been classified as highly dense; moderately dense and scrub forests. Over the last 10 years there has been considerable change in forest cover which can be established from satellite data and that available with the forest department. While there has been some afforestation, the species grown are different from the natural vegetation.

Mangrove forests are ecosystems which provide a number of benefits to the community, some of which are marketed, others are non-marketed, some being on-site, others off-site. The easily identifiable goods that are marketed are poles, small timber, charcoal, tanning from the bark of the mangrove trees, crabs, crustacean and fish. They also provide habitats for aquaculture of shrimps, mollusk, fish, salt and honey production. The non-marketed include medicinal values of mangrove produce, phalloid feeding ground, shelter for birds, recreational value, etc. In addition, the mangrove ecosystem provides a number of environmental services, such as that of stabilizing the coastline, buffering the coast against storm damage, providing nutrient flows to the estuaries, and conservation of genetic resources.

Industry

There are both large and small industries in Goa. A large number of industrial estates have come up in the state to promote both decentralization and to enable industry to benefit from scale and agglomeration effects. A major problem that the sector faces is of poor quality and uncertain availability of power. The environmental consciousness of its polity is very high, which has resulted in a choice of an industrial policy that allows only non-polluting industries.

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2 Project details

Objective of NRA in Goa

Related to a number of sectors of economic activity, to

- develop physical accounts of natural resource depletion or enhancement and environmental degradation or improvement.
- value, in economic terms, natural resource depletion or enhancement and environmental degradation or improvement (to the extent possible).
- adjust state domestic product to account for natural resource depletion or enhancement and environmental degradation or improvement.

Scope

The accounts that will be prepared are, where possible, for the years 1991 and 1996:

- Land use by sector, physical accounts
- Minerals, physical and monetary accounts
- Forests, physical and monetary accounts
- Groundwater resources, physical and monetary accounts
- Water degradation, physical and monetary accounts
- Air degradation, physical and monetary accounts
- Solid waste, physical accounts

Methodology and data availability

Overview

The accounts will be made in three stages:

1. Physical accounts linking economic activities to natural resource depletion and environmental degradation.
2. Economic valuation, where feasible, of the physical accounts in step 1.
3. Adjustment of state domestic product.

The rest of the section will give a more detailed description of the methodology and data availability of each account in turn.

Land-use accounts

Methodology

These will essentially be snapshots at two different time periods of land under different kinds of economic activity: agriculture, forestry, mining etc.

There are three options:

1. Numerical land-use accounts by simply aggregating numbers for land-use at the taluka level.
2. Remotely sensed mapping of different kinds of land-use. This would require using photographs from airplanes, and interpreting satellite imagery, to update the land-use maps.
3. Digital image processing of satellite imageries.

Expertise to carry out the land-use accounting on GIS exists in the Town and Country Planning, Environment, Mining, and Forestry Departments.

Data availability

Option 1: Data is available with the Directorate of Planning, Statistics and Evaluation, Government of Goa.

Option 2: Aerial photographs available with Forest Department, Department of Mines, Town and Country Planning Department, and Department of Environment. Some satellite imageries are available with the Department of Environment, and the latest should be procured from the National Remote Sensing Agency, Hyderabad.

Option 3: Digital imagery is available with the National Remote Sensing Agency, Hyderabad.

Previous related work

TERI has mapped the mining areas in Goa, and we are shortly going to map the coastal villages of Goa also, which should enrich the land-use accounts.

Mineral resource accounts

Methodology

Physical accounts

Physical accounts provide a measure of resource availability in the short or medium term. The basic accounting identity for the preparation of physical accounts is:

`Closing stock = opening stock + reserve accretion - production`

Where closing stock is the quantity of remaining recoverable reserves at the end of the year after making deductions for production (depletion) and reserve accretion from the opening stock of recoverable reserves. The remaining recoverable reserves (closing stock) at the end of this accounting period is equal to the opening stock at the beginning of the next year.

Monetary accounts

The method of valuation of mineral resources can be the net price method; the user cost method, or the present value method. A brief description of each follows.

- Present value method. The present value V_0 of a natural resource is the sum of the expected net revenue flows N_tQ_t, discounted at nominal or real interest rates r for the life T of the asset:

  $$V_0 = \sum_{t=0}^{T} \frac{N_t \times Q_t}{(1+r)^t}$$

  Where N_t is defined as the total unit value of the resource less the costs of extraction, development, exploration and Q_t is the quantity exploited during the period t.

- Net price method. The value of the resource at the beginning of period t, V_t, is the volume of the resource R_t multiplied with the difference between the average market value of the resource p_t and the per-unit (marginal) cost of extraction, development and exploration, including a normal return to capital c_t

  $$V_t = (p_t - c_t) \times R_t$$

- User cost method. The user cost, i.e. the discounted net revenue from the sale of the resource is:

  $$R - X = \frac{R}{(1+r)^{n+1}}$$

  Where R is the annual net revenue from the sale of the resource, assumed to be constant over its lifetime (of n years). X is the 'true income' element calculated so that R-X represents a capital element whose accumulated investment at an interest rate r during the n years would create a permanent stream of income of X.

Previous related work

Table 4 illustrates an example of mineral resource accounts in the Yamuna sub-basin, carried out by TERI.

Table 4. Physical and monetary accounts for talc/steatite in the Yamuna sub-basin

Accounting category	*1988*	*1989*
Physical accounts		
Opening stock (thousand tonnes)	7263	7222
Production (thousand tonnes)	41	66
Closing stock (thousand tonnes)	7222	9931
Monetary accounts		
Production cost (Rs/tonne)	112	224
Pit mouth value (Rs/tonne)	550	600
Depreciation (Rs thousand)	1681	4356

Source. TERI (1997), p. 95

Data availability

Reserves, production and cost data are available with the regional office of the Indian Bureau of Mines in Goa.

Forest resource accounts

Methodology

Physical accounts

The resource accounts will be as follows (Table 5).

Table 5. Framework for forest resource accounts

- Opening stock
    - Changes due to economic activity
        - Depletion
            - Logging/harvest
            - Logging damage
            - Fuelwood extraction
    - Other accumulation (+/-)
        - Forest conversion to other forest use
        - Forest conversion to non-forest use
    - Other volume changes
        - Additions
            - Natural growth
            - Regeneration
        - Reductions
            - Stand mortality
            - Insect infestation
            - Forest fires
            - Natural calamities
        - Other changes (statistical discrepancy)
- Changes in stocks
- Closing stock

Valuation.

Valuing forests is challenging because forests, particularly tropical forests, provide multiple goods and services. Among them, the following uses are particularly relevant:

Consumptive Direct Uses

Timber, as raw material for forest based industries and as building blocks, furniture and other uses in industrial and domestic sectors.

Fuelwood, mainly as a source of household energy.

Non Timber Forest Products, for both commercial and subsistence uses.

Non consumptive direct uses

Recreation, particularly in the form of eco-tourism, has gained popularity over the years.

Local indirect uses

Watershed protection, flood protection, and soil retention have been established to be important functions of forests. Deforestation has been linked to loss of land productivity in all land-based activities.

Global issues

Forest development has been identified as one of the low cost mitigation options for the greenhouse effect. Forests sequester carbon, above and below ground, till maturity. The value of this function is increasing over time as the level of carbon dioxide in the atmosphere is rising.

Option Value

Forests provide habitat for biodiversity and act as a storehouse of genes, which has an option value due to the yet unknown but potential uses, including medicinal uses for which there may not be a substitute.

The direct use value lost or gained by reduction or increase in area under forests, and due to reduction or increase in the density of the forests can be valued by estimating the increase or decrease in the sustainable supply of timber and fuelwood.

Contingent valuation

To estimate the willingness-to-pay by people for the other values of the forest, we will use the contingent valuation method. The Contingent valuation method

(CVM) can be used to measure both use and non-use values. The technique determines consumer's preferences by constructing hypothetical markets. It arrives at the willingness to pay to continue receiving benefits and or willingness to accept compensation in returns for foregoing benefits. On the negative side, the debate on the contingent valuation method revolves around the context effects, framing effects, embedding effects and other biases. Also, it is argued that the consumer is not answering questions in a real situation and the value through WTP may be much more that what would have been in the actual market if it were in existence.

Though debates about the strengths and weaknesses of contingent valuation continue, it is being used increasingly. In the USA, evidence of damage to the non-use values of natural resources is admissible in the award of damages to trustees and others. Often, contingent valuation is the only method of estimating these values. The practitioners of contingent valuation got considerable encouragement from the litigation following the Exxon Valdez oil spillage in 1989.

Much depends on the manner in which interview schedules are framed and canvassed among the users (respondents) of the resource. The National Oceanic and Atmospheric Administration (NOAA) Report, commissioned in the aftermath of the Exxon Valdez accident in Alaska, provides guidance for the use of contingent valuation, and is an authoritative pronouncement on its relevance to the estimation of non-use values.

The steps for the contingent valuation estimation are as follows.

1. A preliminary study of the resource we are concerned with and of the issues that are important to the target.
2. Selection of surveyors, and their training.
3. Preliminary survey and questionnaire design.
4. Input and analysis of the survey data.
5. Re-designing the questionnaire.
6. Analyzing the data.

Previous related work.

Table 6. Growing stock in forests of Goa by tree species

Forest type	*Growing stock* (thousand cubic metre)
Western Ghat Evergreen	764
Western Ghat Semi-evergreen	5784
Miscellaneous	6096
Total	12644
Annual increment	231

Source. Ministry of Environment and Forests. 1996. **The State of the Forest Report: 1995.** Dehradun: Forest Survey of India, Ministry of Environment and Forests, 98 pp.

Using physical data on the state of forests in Goa (see for example, table 6), it has been estimated by TERI that the annual loss of industrial wood because the forests in Goa are not as dense as they could be with better management, is of the order of Rs 65 million.

Data availability.

The State of the Forest Report of the Ministry of Environment and Forests provides data on growing stock in the state. The exercise will also draw upon Working Plan information and data generated by the NRSA and other agencies for forest resources.

For the contingent valuation, it is proposed that 400 households be interviewed.

Groundwater resource accounts

Methodology

Physical accounts

Table 7 shows the framework for the physical accounts of groundwater resources

Table 7. Framework for the physical accounts of groundwater resources

Opening stock
-water extraction by sector
+/-changes due to natural changes
+replenishment
Closing stock

Valuation.

The incremental costs of extraction will be used to value the depletion of groundwater resources.

Previous related work

TERI has estimated the future incremental costs of extraction of replenishable groundwater in Haryana (table 8).

Table 8. Future incremental costs of extraction of replenishable groundwater in Haryana

District	*Replenishable groundwater* (million cubic metres/year)	*Number of years to decline to the next horsepower band and for impacts to be felt*	*Value of replenishable groundwater* (Rs million)
Karnal	881	37	371
Panipat	401	31	169
Rewari	193	17	40
Kurukshetra	312	4	66
Mahendragarh	164	8	69

Source. TERI estimates

In Haryana, we equated the value of groundwater with the cost of extracting groundwater from the next depth category. Assuming a constant rate of decline and a continuation of past trends, it will take from 4 to 37 years for the water table to fall low enough to take it to the next depth-category (depending on the horsepower of the pump used for extraction) and for its impacts to be felt. In Kurukshetra district, for instance, in 4 years, the annual incremental cost of groundwater extraction will be 66 million years.

Data availability

Some data is available in the Central Groundwater Board's publication, Groundwater Resources of India, and the Annual report of the Ministry of Water Resources. However, for an in-depth analysis, we would depend on unpublished data with the State Groundwater Board.

Degradation accounts for water

Methodology

Physical accounts

The basic equation is:

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Effluent loading = rates of flow
× concentration of pollutants
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Estimating the emissions of water pollutants by different economic sectors is a difficult task due to data shortages. However, some amount of primary survey, and use of emission coefficients should enable estimation of the emissions of water pollutants by some economic sectors (Table 9).

Table 9. Framework for water degradation accounts

Economic sector	*Pollution generation (BOD or COD)*
Tourism (Hotels)	
Mining	
Industries	
Households	

Valuation

The physical accounts will be valued by using the maintenance cost method. Maintenance costs are defined as the costs of using the natural environment, which would have been incurred if the environment had been used in such a way that its future use had not been affected.

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Maintenance cost = annualized cost per unit of
pollutant reduction × targeted pollutant reduction
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Previous work.

Table 10 illustrates previous work done by TERI for valuation of water pollution.

Table 10. Incremental annual cost of ensuring drinking-water security in India

Measure	*Cost* (Rs billion)
100% sanitation cover and sewage treatment in urban areas	30.5
100% sanitation cover in rural areas	40.8
100% piped drinking water supply in urban areas	22.5
Treatment of industrial effluents	27.8
Total	121.6

Source. TERI estimates

Data availability

Secondary data is very limited. We will have to conduct primary surveys.

- Water pollution by mining. In this case, we have data on concentrations, and to convert these to loadings, we need to conduct surveys of flow rates at different locations.
- Water pollution due to sewage from hotels and households. We would first contact the local Sewerage Board and the Water Supply Board, and decide the sampling locations based on the drainage and sewage maps. We propose to carry out sampling at 60 different locations in Goa.

Environmental degradation accounts for air

Methodology

Physical accounts

Two kinds of physical accounts will be prepared:

1. Emissions inventory
2. Exposure accounts

Emissions inventory

The emissions inventory documents the emissions of air pollutants by different economic sectors (see table 11).

Table 11. Framework for emissions inventory

Economic sector	*Emissions*					
	CO	*HC*	*NOx*	*SO2*	*TSP*	*Pb*
Transport						
Mining						
Industries						
Households						

The steps for estimation are:

1. Establish the source inventory; classifying sources into: transport, domestic, power and industry.
2. For each source, using norms and averages, estimate fuel consumption.
3. Use the identity, fuel consumed = fuel supplied, normalizing estimates of fuel consumption from the demand side (which are more disaggregated) with figures of total supply of fuel on the supply side (which are more aggregated).
4. Apply emission factors to fuel consumption, to get the emissions of different air pollutants by source category.

Exposure accounts

The exposure accounts document the exposures to air pollution by different classes of population. The assessment of daily exposure entails measuring concentrations of pollutants in important micro-environments and obtaining information through a questionnaire based survey on the time spent by the target population in different micro-environments. The daily integrated individual exposure is computed as follows.

$$E = \sum_{i=1}^{m} C_i t_i$$

Where E = integrated daily exposure of an individual, Ci = concentration in the ith micro-environment, ti = time spent by an individual in the ith micro-environment, and m = number of micro-environments for an individual.

Here,

$$\sum_{i=1}^{m} t_i = 24h$$

Valuation

By maintenance cost.

Maintenance cost = annualized cost of measures/unit emissions reduction × target reduction

Previous related work

Table 12 shows TERI's estimates of emissions of criteria pollutants in Panipat from the transport, domestic and power sectors.

Table 12. TERI's estimates of emissions of criteria pollutants in Panipat district from the transport, domestic and power sectors (thousand tonnes/year): 1993/94

Pollutant	*Transport*	*Domestic*	*Power*
CO	3203	9391	1780
HC	1305		890
NOx	1781	22	4700
SO2	183		14777
SPM	268	1381	28486
Pb	1		

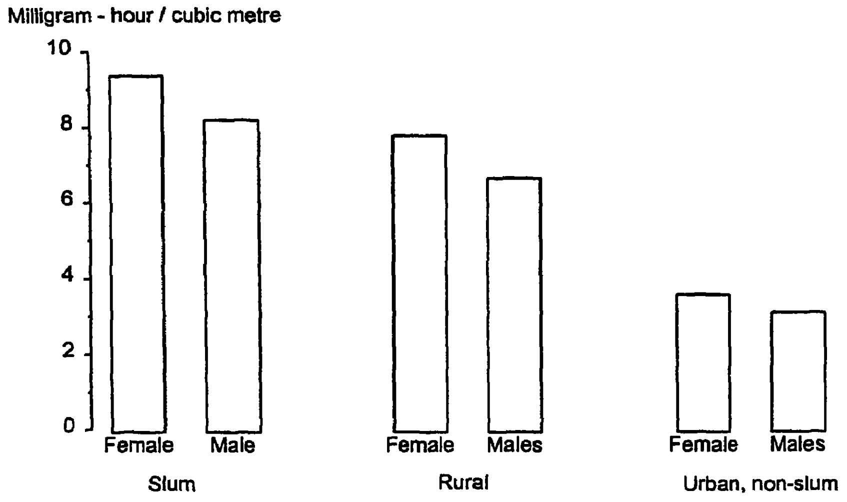

Figure 2. TERI's estimates of mean exposure to particulate matter

Figure 2 illustrates work done by TERI on exposure assessment for India.

Data availability

For emissions inventory, the data varies across sectors, being good for the transport and domestic sectors, and generally weak for the industry sector. In the industry sector, a primary survey may have to be carried out for the fuel consumption by large and medium industries in Goa.

For the exposure accounts, it is proposed that monitoring of indoor air be carried out of 100 households, of which 50 households will be those of mining workers. A baseline socio-economic and time budget survey of 1000 households will help generalize the results of the primary survey to the rest of the population.

Accounts for solid waste generation

Methodology

Table 13 is the framework of the accounts for solid waste. These will be in physical terms only, and for tourism (hotels) and households.

Table 13. Framework for solid waste accounts.

	Waste generation						
Economic sector	*Ash, fine earth*	*Compostable matter*	*Paper*	*Plastics*	*Metals*	*Glass*	*Rags*
Tourism (hotels)							
Households							

In addition, the data that TERI has on solid waste generation by mining will also be tabulated.

Previous related work

Very little work has been done in the area of quantification of solid waste generation in India. Three surveys which have been conducted in the past by different researchers are Bhide and Sundaresan (1984), Nath (1984), and Environment Protection Training and Research Institute (1995).

Data availability

Secondary data on solid waste generated is not available. A primary survey will be carried out of waste generated by about 400 households, for three times in a season, and for four seasons. Waste samples will be collected and then analyzed for physical content.

Adjustment of state domestic product

The adjustment of state domestic product will be as follows.

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Environmentally adjusted state domestic product
= Net state domestic product
± value of natural resource depletion or enhancement
± value of environmental degradation or improvement
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Work Plan

Over a two and a half year period,

- Training seminar with members of project team from Directorate of Statistics, Planning and Evaluation, Goa and other state departments
- Secondary data collection
- Primary surveys

- Physical accounts construction
- Valuation
- Adjustment of state domestic product
- Draft report
- Final report

Budget

The budget depends on a variety of factors: the number of resources and pollutants covered and the methods used to study them; the degree of participation by State Government personnel and the availability of facilities such as accommodation in state guest houses. The following estimate (Table 14) is if all the accounts we have mentioned are covered, and if TERI researchers do all the work.

Table 14. Budget for NRA in Goa

Head	*Number*	*Rate*	*Rs*
Time by Fellows	10 person months	37,000/month	3,70,000
Time by Research Associates	90	27,000/month	24,30,000
Travel			5,50,000
Equipment			6,00,000
Surveys			15,00,000
Overheads			5,45,000
Total			59,95,000

3 TERI's capabilities in NRA

TERI

TERI (Tata Energy Research Institute) studies and seeks solutions to the immense problems that arise consequent to the rapid depletion of natural resources, and the serious environmental hazards that arise from their use. Natural resource accounting is one of the important research activities that TERI has been pursuing in the last few years.

Inter-disciplinary team

TERI's strength lies in its ability to quickly put together teams of professionals with specific skills to match the requirements of a particular project. In this project, TERI will put together a team from the following three 'Areas' within TERI.

- Resource and Development Economics. This Area aims to promote the sustainable use of natural resources and the environment through the application of integrated environmental, social and economic analysis.
- Centre for Environmental Studies. This Area examines environmental issues in urban, industrial and rural settings. The methods have included field surveys, experiments and mathematical modelling.
- The Western Regional Centre of TERI, based in Goa. This Area carries out policy research in mining, tourism, groundwater use, agriculture, environmental implications of coastal area development and forestry.

The team will have the following inter-disciplinary skills: field monitoring for air, water, solid waste, and noise pollution; economic valuation of degradation and depletion; and skills at using GIS (Geographic Information Systems); assessment of forest growing stock and sustainable yield.

Experience in Natural Resource Accounting

TERI has done two projects in Natural Resource Accounting so far:

- *Adjusting GDP for depreciation of coal, soil and forests.* Perhaps the first Indian empirical estimates of natural resource degradation was the valuation of depletion of India's coal, forests and soil by TERI (TERI 1994). This study tried to highlight the discrepancies in the existing system of national income accounts and to amend these to account for natural resource depletion. Specifically, the study developed the physical accounts, valued the depletion and adjusted the gross domestic product to take note of the cost of depletion of soil, coal and forests.

- *Natural resource accounting in the Yamuna sub-basin.* The Ministry of Environment and Forests commissioned this large study of natural resource accounting in the Yamuna sub-basin. A number of institutes, including the Institute of Economic Growth, NEERI, CISMHE, and TERI, collaborated on this project. This project studied a range of resources in the region, including land, air, water, and minerals. In this project TERI built accounts for energy and emissions; accounts for minerals; analysed the impact of agricultural activities; and studied the exposures of the population in the Yamuna sub-basin to air pollution and air pollution related health impacts.

Environmental research in Goa

- *Population, consumption and environment: a tourist spot scenario* (ongoing)

  A study of the impacts of tourism-induced in-migration and tourism related infrastructure on the coastal environmental resources of Goa.
- *Training and policy guidelines for artisanal mining and quarrying: case study in Goa* (ongoing).

  Will produce complimentary case studies in a different regulatory environment to assist in defining the most appropriate technical and policy level interventions for artisanal quarrying in Kenya.

  Will assess the environmental impact and economics of laterite quarrying in Goa.

  Will suggest improvements in operating these quarries.
- *Area wide Environmental Quality Management Plan for the Mining Belt of Goa.* (completed).

  A detailed study of the environmental and socio-economic situation, present conditions and problems vis-à-vis various developmental programmes in the mining belt.

  Formulated and analysed environmental quality management strategies and evaluated these management strategies for the cost effectiveness and implementability in the mining belt.

  Suggested a detailed approach to be followed by the Government for ecology, transportation, waste disposal, technology etc. as well as the institutional and administrative arrangements required for its implementation and monitoring from time to time.

  Provided an estimation of funds required for effective implementation of these strategies.
-

- *Villages around Sonshi and Codli Mines: a survey report* (completed)
  Arrived at a socio-economic profile of 6 mining villages.
  Determined issues of concern to the local community.
  Obtained suggestions from the local community about the kind of schemes and programmes that would be of interest to them.
  Suggested follow-up measures to the company.